OLD DOMINION UNIVERSITY RESEARCH FOUNDATION

DEPARTMENT OF GEOPHYSICAL SCIENCES
SCHOOL OF SCIENCES AND HEALTH PROFESSIONS
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA

TECHNICAL REPORT GSTR NO. 82-6

DEVELOPMENT OF DATA PROCESSING INTERPRETATION AND ANALYSIS SYSTEM FOR THE REMOTE SENSING OF TRACE ATMOSPHERIC GAS SPECIES

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Progress Report
For the period January 22, 1981 - January 21, 1982

Prepared for the
National Aeronautics and Space Administration
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Under
Cooperative Agreement NCC1-34
Henry G. Reichle, Jr., Technical Monitor
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P. O. Box 6369
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INTRODUCTION

The Cooperative Agreement, NCC1-34, between NASA/Langley Research Center and Old Dominion University, entitled "Development of Data Processing - Interpretation and Analysis System for Remote Sensing of Trace Atmospheric Gas Species" has represented a major research effort during the period of January 1981 to November 1981. Research work performed by ODU specifically addressed problems associated with the development of the MAPS experiment program being conducted at NASA/LaRC. The primary thrust of this research has been the utilization of the MAPS experiment data in three application areas:

(1) low altitude aircraft flights (one to six km)

(2) mid-altitude aircraft flights (eight to 12 km)

(3) orbiting space platforms.

Extensive research work in four major areas of data management has been the framework for implementation of the MAPS experiment technique. These areas are:

(1) data acquisition

(2) data processing, analysis and interpretation algorithms

(3) data display techniques, and

(4) information production.

The accomplishment of these tasks under this agreement is ongoing and has required major developmental research and analysis of two large MAPS experiment data sets, the 1978 St. Petersburg, Florida data and the 1979 MONEX data. Portions of the methodology and operational software developed in the analysis of these two extensive sets of data have been applied in the MAPS/OSTA Space Shuttle data reduction plan and software schema.

A major contributing factor in the successful progress of these research tasks has been the implementation of the Tektronix 4052 desktop graphics system in the computation work requirement. Use of the Tektronix 4052 desktop graphics system, both in the stand-alone mode and as an online terminal, increased significantly during this reporting period. This system has shortened the turn-around time for computer results, especially in the form of graphics output, and has added to our capability of summarizing data with quickly produced, highly accurate graphs and with mathematical curve fits. Diverting computer work to the Tektronix system has been a contributing factor in the reduction of expenditures, approximately a factor of two savings by the MAPS ODU personnel, for the use of NASA operated computers. Currently, computer costs are within budget rather than exceeding allocations as has occurred in recent fiscal years.

Large amounts of data are currently stored on Tektronix floppy disks at essentially no cost, discounting the initial

investment in this computer system. If required, this data can be transferred to the NASA computing facility, a process which is not excessively time-consuming when accomplished at 1200 baud. This equipment is located off-site in the Research Drive office complex and is accessible at all times, therefore greatly extending our capabilities beyond the limitations of regular weekday accessibility to NASA computing facilities. "Down time" due to hardware failure has been negligible, and hardware data processing has been excellent.

Operating as an on-line hookup to the NASA computer network, the Tektronix system has greatly decreased the time required to "debug" new graphics software. Past unavoidable delays in the generation and delivery of paper plots were eliminated when graphics output could be previewed on the 4052 system terminal screen. Corrections, changes, and enhancements to the graphics images are now possible before the final output is routed to a permanent medium plotting device. High quality graphics output are produced by the Tektronix 4663 interactive digital plotter. These images are easily enlarged or reduced according to the needs of the user. Multicolor plots can also be generated to add emphasis, clarity, or simple eye-appeal. The DEC-10 computer operated at the main campus of ODU is also accessible to the Tektronix system. To facilitate program development, files such as the meteorological models under development were transferred from ODU to NASA and vice versa via telephone lines with intermediate storage on the Tektronix cartridge tape.

Offline this system was used largely for data display and curve fitting, using both software purchased from the vendor and code created in-house. The BASIC programming language built into the system was mastered readily by all users. In addition to coding numerous special purpose programs in BASIC, a general utility plotting package was written and executed extensively. This program displays one or more sets of coordinate pairs on either linear or logarithmic axes. The user controls scale factors, titles, symbols, and the optional inclusion of a curve representing a "best fit" of the data by one of several linear equations. This package also displays statistics including maximum and minimum residuals and estimated values of the dependent variable. The implementation of this computer graphics system in the performance of research work by ODU personnel has resulted in incalculable cost savings in computer expenditures by NASA.

Although the research being performed by ODU is currently under a continuation agreement of NCC1-34, specific developmental accomplishments in the data management organization have been successfully performed for low altitude and mid-altitude aircraft experiments. These research tasks addressed work in three areas, St. Petersburg Test Flight data, the 1979 Summer MONEX data, and MAPS/OSTA Experiment integration and testing.

ST. PETERSBURG FLIGHT TEST - LOW ALTITUDE

In August 1978, low altitude aircraft flight tests were conducted using the MAPS Brassboard GFCR to measure the column burden of carbon monoxide (CO) in the St. Petersburg - Clearwater urban areas of Florida. The data acquired during these flight tests provided a data base for the evaluation of the performance of the GFCR sensor system and for the testing of refinements to the data reduction method of the MAPS experiment. Research work performed utilizing this GFCR data improved the data reduction procedure for MAPS.

These flight tests evaluated the effects of the MAPS instrument output signal to hot and humid subtropical atmospheric conditions; to partial cloud cover in the field of view; and to varying surface (land or water) emissivities. Analysis of independently obtained CO vertical mixing ratio profile data obtained from the flight tests was used to characterize the spatial and temporal variations of CO within this urban study area.

The St. Petersburg Peninsula on the west coast of Florida was selected as a test site because it is located in a subtropical climate and is adjacent to the Gulf of Mexico, which is a non-source CO area. This test site also provided a data set with variable cloud distribution (both type and coverage) as well as variable contamination sources. Sufficient emission inventory and simple geographic distribution of sources at this test site simplified the data analysis procedure used in the verification of the MAPS CO measurement technique.

Experimental Details

To perform the St. Petersburg experiment, a Cessna 402B (N69402) twin engine aircraft with a crew of three (pilot, flight coordinator, and sensor operator) was equipped with the MAPS Brassboard GFCR, Precision Radiometric Thermometer (PRT-5), hygrometer system, total temperature probe, altitude pressure transducer, Loran route verification system, 35 mm aerial camera, and a Loran navigational system.

Six flights were flown from August 14 to August 17, 1978, over the St. Petersburg - Clearwater area, as shown in Figure 1. Remote sensing data were collected during three flights at an altitude of 6.1 km and three flights at an altitude of 2.4 km. Shown in Table 1 are the beginning and ending times of the flights and the latitudes at which the data were collected. The first and third flights were chosen for detailed data reduction and will be referred to in this paper as Flight I and Flight II, respectively.

For each flight the Cessna 402B departed the St. Petersburg - Clearwater International Airport, ascending at a rate of 3.6 m/sec to flight altitude. This procedure required about 30 minutes during which time the MAPS instrument was cycled through a balance/calibration sequence. The aircraft pilot entered the test pattern at location BALL labeled in Figure 1 and proceeded in a counterclockwise flight direction along the defined aircraft ground track, requiring approximately 45 minutes.

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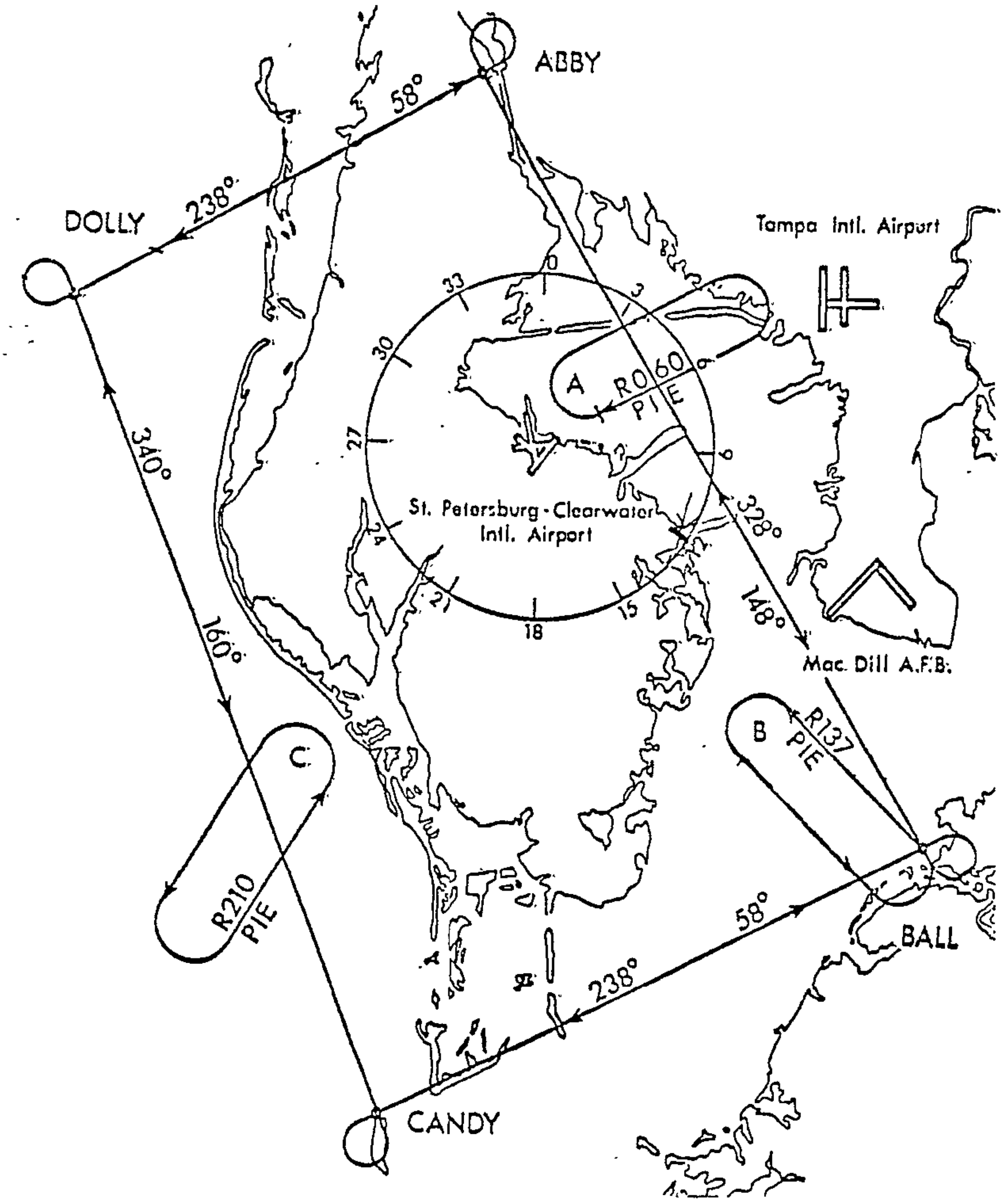

Figure 1. St. Petersburg ground track.

Table 1

Beginning and ending flight times

Flight no.	Date	Approximate Start	Approximate Stop	Alt km
1	Aug. 14, 1978	1458 hours (LDT)	1740 hours (LDT)	6.1
2	Aug. 14, 1978	1828	2100	2.4
3	Aug. 14, 1978	2152	0100	6.1
4	Aug. 15, 1978	0125	0430	2.4
5	Aug. 16, 1978	0614	0930	6.1
6	Aug. 17, 1978	1018	1253	2.4

The MAPS instrument was recycled through a balance/calibration sequence prior to the aircraft commencing a race track pattern, descending over BALL. During the descent, the aircraft was flown straight and level for approximately two minutes at each of the nine different altitudes where GFCR data and ambient air samples were obtained.

Measurements

The inflight data collected consisted of radiometric surface temperatures; two GFCR output signals: ΔV_{cell}, containing the gas of interest, and V_{cell}, a vacuum cell; ambient air samples, total air temperature at flight altitude, dewpoint temperatures at flight altitude, and altitude in feet.

Inflight analog output signals of the flight instrumentation was recorded by a Pulse Coded Modulation (PCM) digital recording system. The analog signals of the instruments were digitized and stored in binary format on seven-track computer compatible tapes. (1) The PCM system recorded one record every twelve seconds. Records contained 31 frames of data and were separated by a one frame inner record gap.

Data Reduction Procedure

A schematic of the procedure used to reduce the GFCR data obtained at St. Petersburg is shown in Figure 2. The first step in the data reduction procedure was to utilize computer code to select every fifth frame of data from the PCM tape,

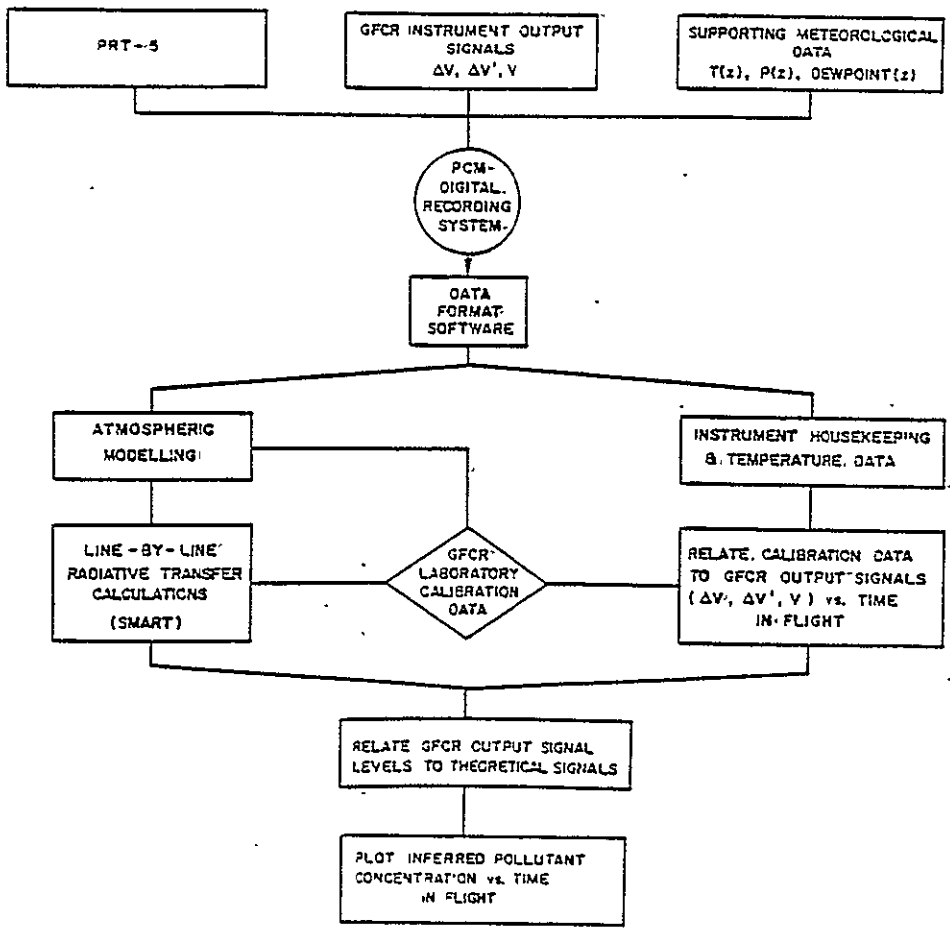

Figure 2. GFCR data reduction procedure.

starting with the first frame, and create a file which retained the same 32-frames per record format as the original tape. This file, which contained only a sampling of the PCM data, was used as input to another computer program which averaged selected parameters within each frame. The averaged data corresponds to a frame sampling rate of approximately 2.67 frames per second. A flow diagram of this procedure is shown in Figure 3.

The data processing procedure to this stage was accomplished on the CDC Cyber computer network maintained by the Analysis and Computation Division (ACD) of NASA/LaRC. Averaged values of the data were transferred to the Tektronics 4052 graphics system at the Old Dominion University Research Foundation office in Hampton for final data reduction.

The next step in the data reduction process was to use the meteorological parameters, outside air temperature, pressure, and dewpoint temperature, obtained during the periodic descent of the aircraft, in the initialization of a computer program that simulated the overall atmospheric radiation characteristics during the time of the GFCR measurements. This modeled atmosphere, which characterized the temperature, pressure, and water vapor distribution, was used to compute the optical thickness specifications of a multi-layered homogeneous atmospheric model. This modeled atmosphere, composed of the average layer values for the temperature, pressure, and volumetric water vapor mixing ratios, was used as the initial atmospheric conditions for SMART. A major

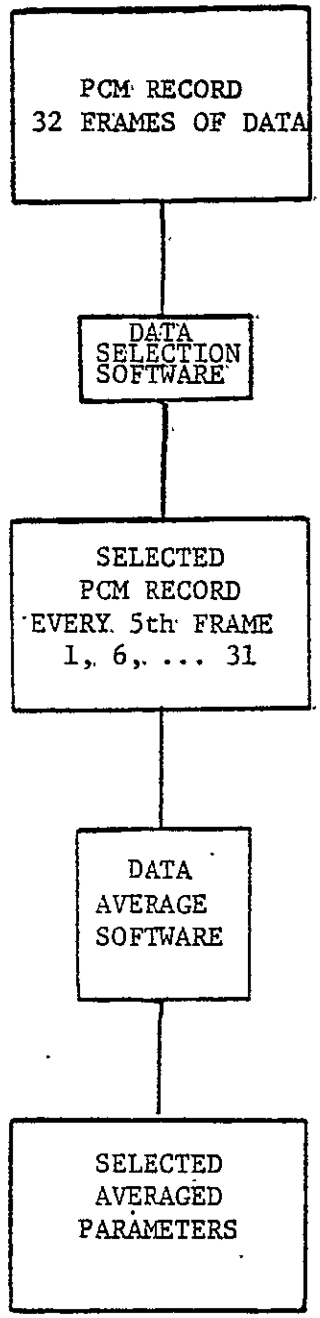

Figure 3. PCM data reduction procedure.

element in the data reduction procedure, the radiative transfer calculations, was accomplished by using the SMART program. The tables of theoretical radiances (N) and differential radiances (ΔN) generated by SMART were parameterized, thus establishing a mechanism by which CO mixing ratios could be obtained for the selected atmospheric conditions. The next step was to use the GFCR flight data and the parameterized SMART values as input into a computer program that computed the CO mixing ratio for a given radiance (N) and differential radiance (ΔN) value. Plotting CO mixing ratios versus time in flight was the final step.

One input parameter to the SMART program is the number of homogeneous absorbing layers, which comprises the total number of modeled atmospheric, instrument, and calibration layers. The modeled atmosphere was partitioned at the descent altitudes of the race track pattern, ensuring no large variation in the modeled atmospheric temperatures within the vertical dimension of a layer.

The CO mixing ratio values were chosen to bracket the expected range of CO values in the geographical area of interest. Shown in Table 2 are the mixing ratios obtained from the gas multipliers used for this study. The background CO mixing ratio was assumed to be uniformly distributed in the vertical with a CO mixing ratio of 1.0E-7.

Shown in Table 3 are the specified model atmospheres for Flight I and Flight II. The temperatures of the layers are expressed in degrees Kelvin, the pressure of each layer is

Table 2

Mixing ratio values and surface temperature

CO mixing ratios (ppbv)	
0	150
50	200
75	300
100	400
125	500

Surface temperatures (K)	
298.16	308.16
300.16	310.16
302.16	312.16
304.16	314.16
306.16	316.16

Table 3

The modeled atmospheres for Flights I and II

Temperature K	Pressure atm	Thickness cm
	Flight I	
302.6	.9890	15200.
301.9	.9720	16800.
299.3	.9440	32000.
296.9	.9090	32000.
294.1	.8760	29000.
292.3	.8450	30400.
290.1	.8150	29000.
288.4	.7850	32000.
285.5	.7550	30500.
283.7	.7140	57900.
279.6	.6370	121900.
274.3	.5650	61000.
269.9	.5210	60900.
266.8	.4890	30500.
266.0	.4680	33500.
	Flight II	
300.50	.9890	15200.
299.60	.9720	16800.
298.20	.9440	32000.
295.90	.9090	32000.
292.90	.8760	29000.
291.40	.8450	30400.
290.60	.8150	29000.
288.90	.7850	32000.
286.60	.7550	30500.
285.10	.7140	57900.
280.60	.6370	121900.
274.90	.5650	61000.
279.20	.5210	60900.
266.20	.4890	30500.
266.40	.4680	33500.

expressed in atmospheres, and the thickness of each layer is expressed in centimeters.

The parameterization of the theoretical radiance and differential radiance values computed in SMART was accomplished using mathematical fits to represent the CO mixing ratio as a bivariate function (i.e., the CO mixing ratios are a function of radiance and differential radiance values). The surface temperatures spanned the range of measured surface temperatures observed during the flights.

Mathematical fits were used to parameterize the bivariate characteristics of the SMART radiance values. A fourth degree least squares polynomial fit was used to represent CO mixing ratios as a function of theoretical differential radiance (ΔN) values for a family of varying surface temperature curves. A third order least squares polynomial fit was used to represent the coefficients (α) obtained from the first fit as a function of a particular theoretical radiance (N) value. The radiance value used for this study was based on a nominal CO mixing ratio of 100 ppbv. The coefficients (β's) obtained from the fit of the first coefficient will be used to determine the mixing ratios of CO from the GFCR data.

The inflight GFCR data were converted from electrical units to physical units by linearly interpolating on the calibration curves. The radiometric and differential radiance signals in the bivariate fits were used to determine the CO mixing ratios by interpolation. This was accomplished by first determining the α's from the radiance values and the β

coefficients. Then the α's and differential radiance are used in an equation that infers the CO mixing ratios for a particular radiance and differential radiance value. The computations shown below use a radiance (N) and differential radiance (DN) obtained from inflight data. The beta coefficients were computed by parameterization of SMART tables generated for this flight. The alpha coefficients (Equation set II) were computed from the given β and N values and used, along with DN, to determine the mixing ratios. Data were taken at an altitude of 6.1 km over a water surface.

Relative differences between fit and corresponding theoretical SMART values are summarized in Table 4. These data are applicable to water and land surfaces at temperatures of $298^{\circ}K$ and $304^{\circ}K$. Figure 4 is a plot of the bivariate fit (solid curves) and the SMART discrete values (symbols) representing data values over a water surface at three surface temperatures ($298^{\circ}K$, $304^{\circ}K$, and $306^{\circ}K$).

$$
\begin{aligned}
MR_1 &= \alpha_{11} + \alpha_{12}\, DN + \alpha_{13}\, DN^2 + \alpha_{14}\, DN^3 \\
MR_2 &= \alpha_{21} + \alpha_{22}\, DN + \alpha_{23}\, DN^2 + \alpha_{24}\, DN^3 \\
MR_3 &= \alpha_{31} + \alpha_{32}\, DN + \alpha_{33}\, DN^2 + \alpha_{34}\, DN^3 \\
MR_4 &= \alpha_{41} + \alpha_{42}\, DN + \alpha_{43}\, DN^2 + \alpha_{44}\, DN^3 \\
MR_5 &= \alpha_{51} + \alpha_{52}\, DN + \alpha_{53}\, DN^2 + \alpha_{54}\, DN^3 \\
MR_6 &= \alpha_{61} + \alpha_{62}\, DN + \alpha_{63}\, DN^2 + \alpha_{64}\, DN^3
\end{aligned}
\tag{I}
$$

$$
\begin{aligned}
\alpha_{x1} &= \beta_{11} + \beta_{12}\, N + \beta_{13}\, N^2 \\
\alpha_{x2} &= \beta_{12} + \beta_{22}\, N + \beta_{23}\, N^2 \\
\alpha_{x3} &= \beta_{31} + \beta_{32}\, N + \beta_{33}\, N^2 \\
\alpha_{x4} &= \beta_{41} + \beta_{42}\, N + \beta_{43}\, N^2
\end{aligned}
\tag{II}
$$

N = 2.52E-5 ($watts/cm^2$ - sr)

DN = 4.15E-7 ($watts/cm^2$ - sr)

Beta Coefficients

9.832E-8	7.733E-1	-4.627E-5	9.441E-12
-6.419E-3	-2.017E-4	-1.838E-10	-5.202E-17
6.694E-1	2.077E-8	6.205E-14	7.411E-21

α_1 = -2.09E-8

α_2 = .397

$\alpha_3 = -5.32 \times 10^5$

α_4 = 1.04

Mixing ratio = 126.4 ppbv

Table 4.

Errors associated with mathematical fits for water and land surfaces at 6.1 km

Theoretical mixing ratios ppbv	Fit mixing ratios ppbv	Relative difference %	
50	48	-3.6	$\varepsilon = .88$
75	73	-2.0	$T_{surf} = 298$
100	99	-1.4	
125	124	-.6	
150	151	0.4	
200	205	2.5	
50	47	-5.8	$\varepsilon = .88$
75	72	-3.4	$T_{surf} = 304$
100	98	-2.5	
125	124	1.0	
150	151	0.8	
200	210	5.0	
50	48	-3.1	$\varepsilon = .98$
75	74	-1.6	$T_{surf} = 298$
100	99	-1.0	
125	125	-.3	
150	151	.7	
200	206	3.1	
50	47	-5.2	$\varepsilon = .98$
75	73	-2.7	$T_{surf} = 304$
100	98	-2.0	
125	125	-.6	
150	150	1.3	
200	200	5.8	

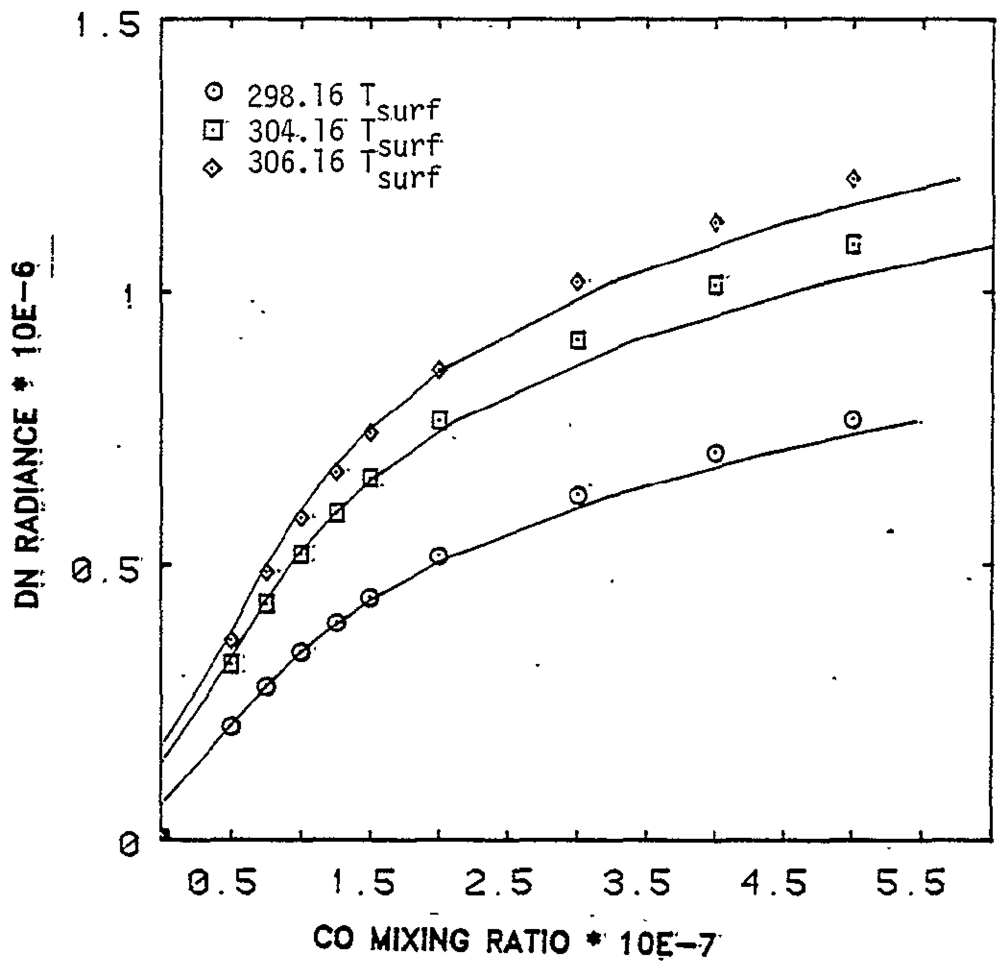

Figure 4. Plot of fit values versus discrete values.

DATA RESULTS AND ANALYSIS

To completely analyze the GFCR data obtained over St. Petersburg, it was necessary to characterize the prevailing meteorological conditions during the period of August 13 through 18, 1978, in the urban area of St. Petersburg. Meteorological data were obtained from several sources. The 850 mb and 500 mb analyses were supplied by the National Weather Service (NWS). Specially launched rawinsondes, corresponding to the approximate times of the aircraft descents, were obtained from the NOAA station at Ruskin, Florida. Normal rawinsonde data for Ruskin and surface observations for Tampa International Airport, St. Petersburg — Clearwater International Airport, Albert Whiting Airport, and MacDill Air Force Base were obtained from the National Climatic Center (NCC) in Asheville, North Carolina. The outside air temperatures and dewpoint temperatures were obtained from aircraft data. Satellite imagery was provided by NOAA.

The atmospheric profiles obtained from the aircraft (Figure 5) were compared to the atmospheric profiles obtained from the rawinsonde data (Figure 6) for Ruskin, and minor differences were observed in the temperature profiles for both flights studied. The implications associated with the minor differences have minimal effect upon the interpretation of the atmospheric profiles. These differences in the meteorological profiles can be attributed to differing sites and times of data acquisition. Aircraft data were taken over water, and rawinsonde data were acquired in land. These comparisons

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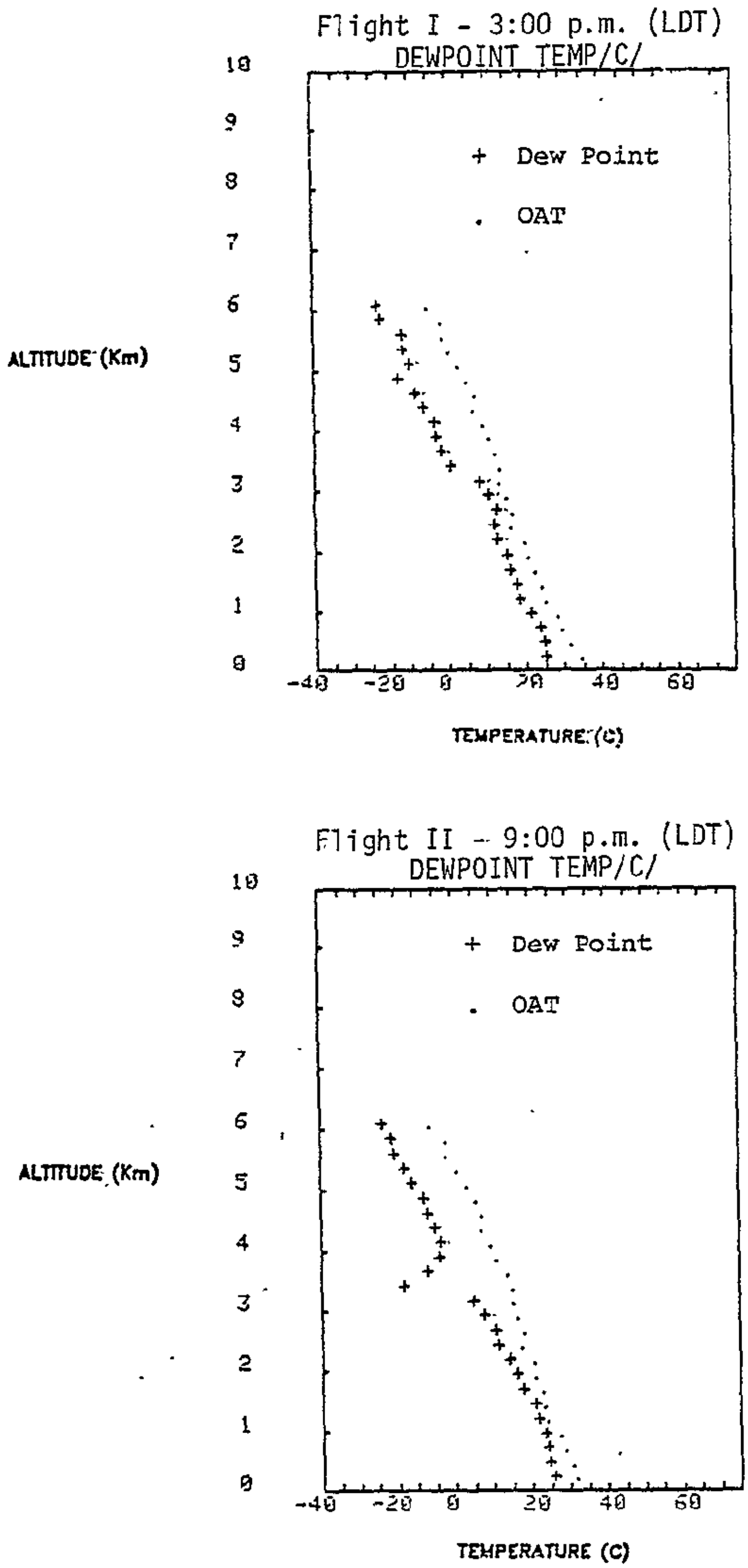
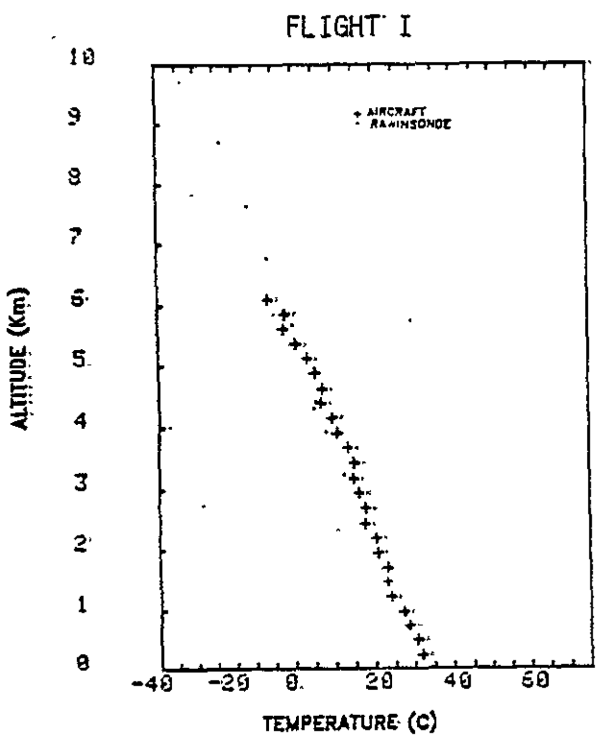


Figure 5. Aircraft profiles for Flights I and II.



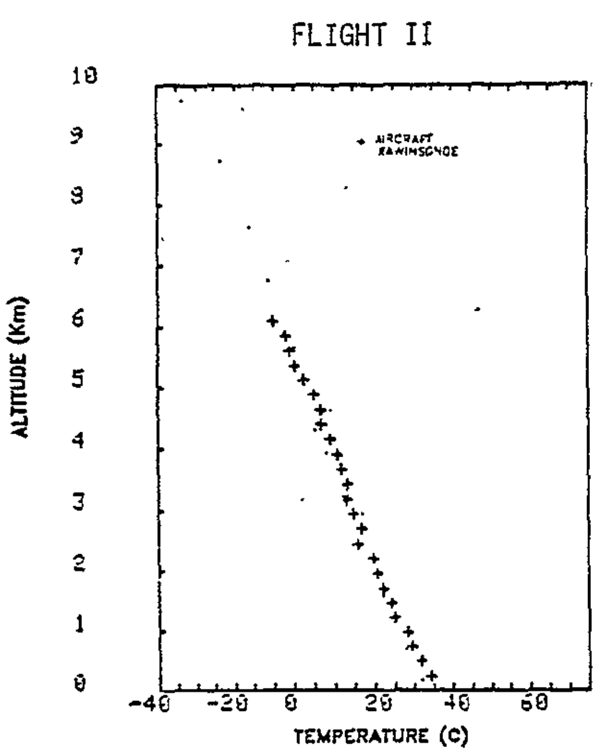


Figure 6. Rawinsonde versus aircraft temperature profiles.

validate the aircraft data and increase the feasibility of using the upper level winds reported by Ruskin in an integrated, detailed analysis of the meteorological and CO data.

CO Measurements

The first data collecting mission was flown on the 14th, commencing at approximately 3:00 P.M. (LDT). The upper level winds at 6.1 km and 5.5 km were out of the south-southwest between 2 and 4.6 m/sec, respectively. Figure 7 shows the GFCR CO mixing ratio measurements and upper level winds superimposed on a map of the area. The average measured CO mixing ratio on the easternmost data leg was 142 ppbv, on the northernmost data leg was 135 ppbv, on the westernmost data leg (over water) was 112 ppbv, and on the southernmost data leg was 112 ppbv.

The second flight started at about 9:00 P.M. on the 14th with the winds out of the north-northwest at approximately 1 m/sec. Shown in Figure 8 are the CO mixing ratios and upper level winds sketched on a background of the region. The average measured CO mixing ratio on the eastern data leg was 86 ppbv, on the northern data leg was 83 ppbv, on the western data leg was 89 ppbv, and on the southern data leg was 89 ppbv.

Vertical profiles of CO were obtained over BALL for both flights after the constant altitude data circuits had been completed. Table 5 contains CO values measured by a gas chromatograph system and CO values from the GFCR analyzed data.

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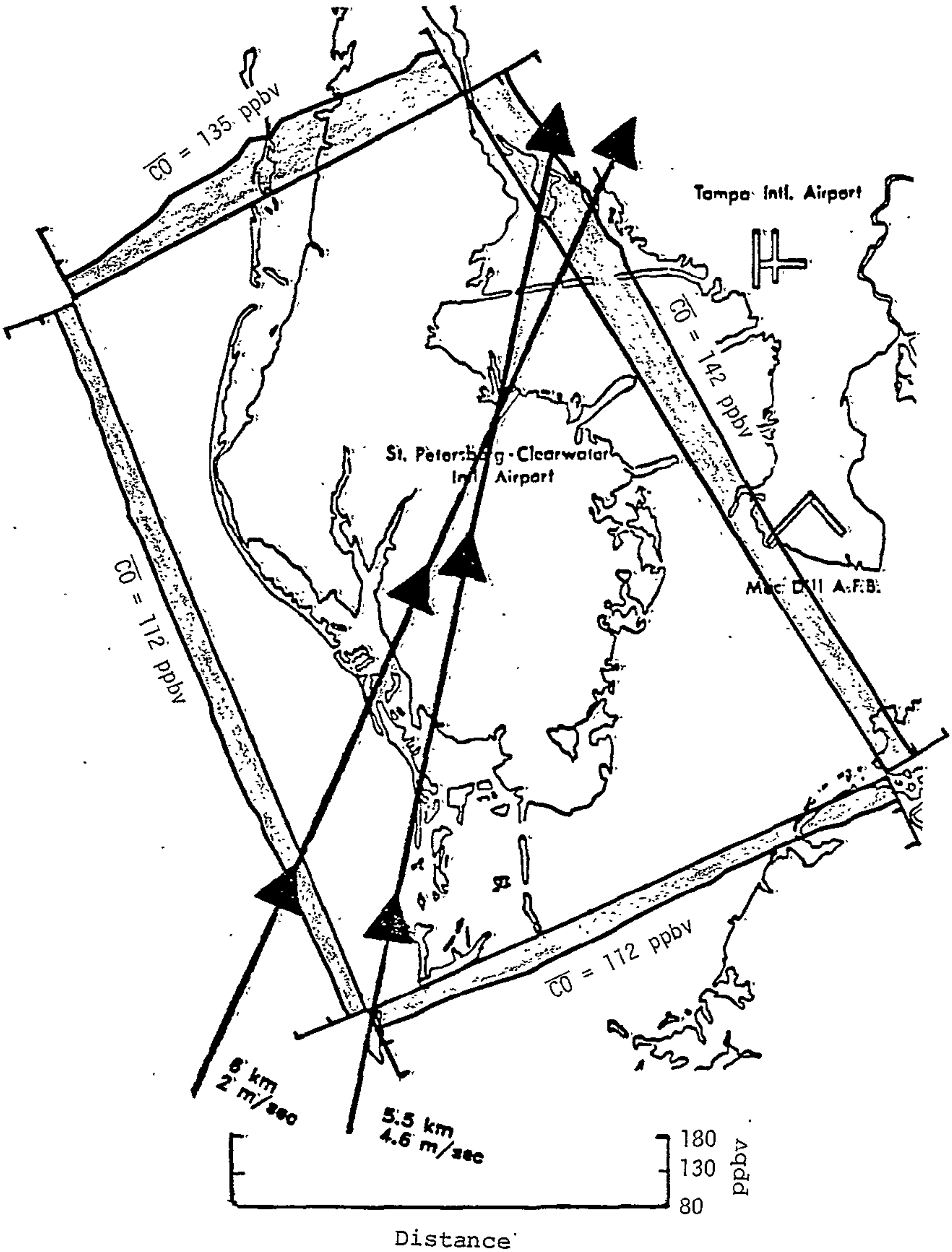
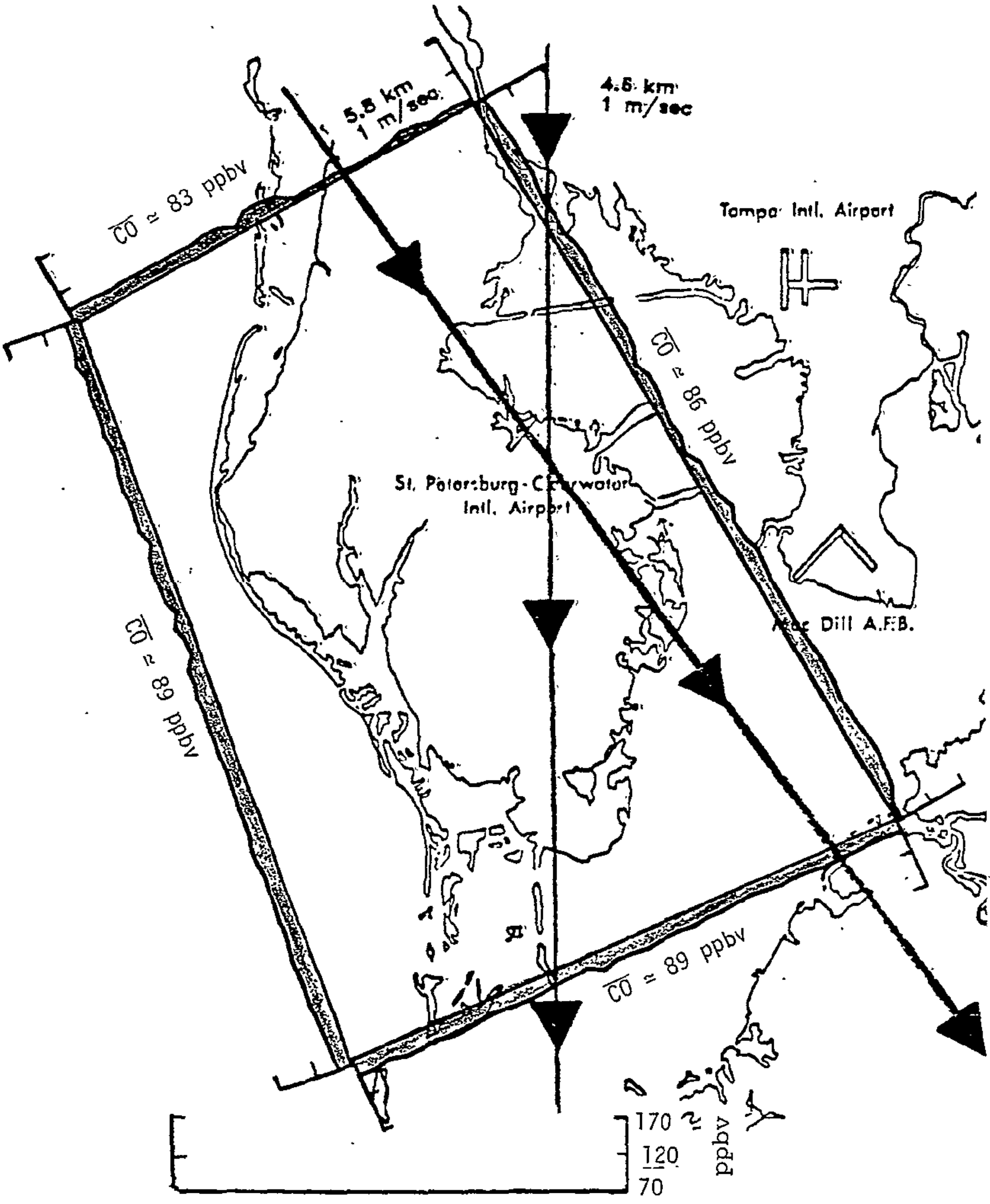


$\overline{CO}$ = average CO values

Figure 7. CO mixing ratios and upper level winds for Flight I.



$\overline{CO}$ = average CO values

Figure 8. CO mixing ratios and upper level winds for Flight II

Table 5.

Vertical CO mixing ratios for GC and GFCR

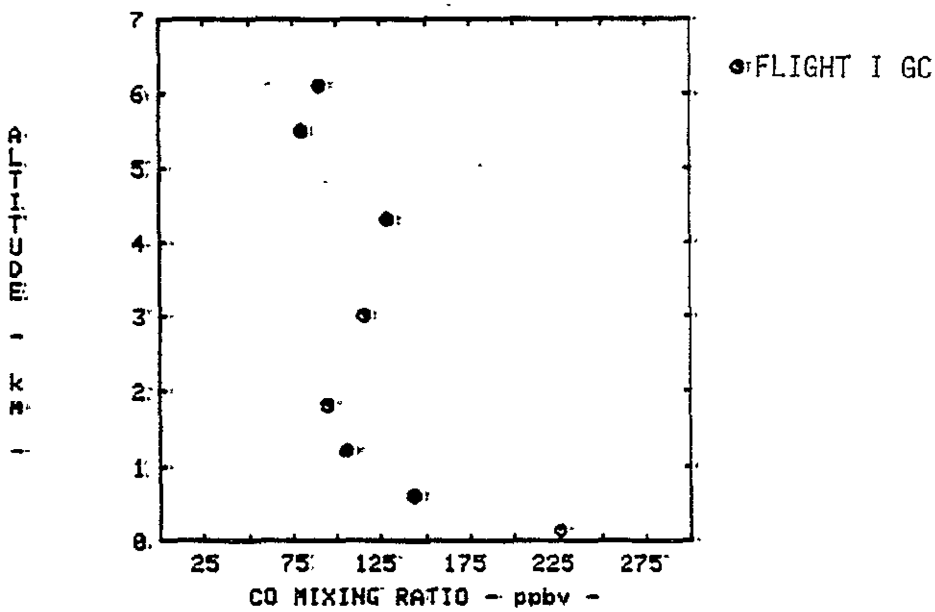
Altitude km	GC Flight I mixing ratio ppbv		GC Flight II mixing ratio ppbv		GFCR Flight II mixing ratio ppbv
-	Point	Column burden	Point	Column burden	
6.1	90	107	70	84	86
5.5	80	110	73	86	77
4.3	129	117	69	88	69
3.0	115	114	77	94	67
2.4	-	-	112	100	108
1.8	95	113	88	94	83
1.2	105	125	90	99	-
0.6	143	157	-	-	-
0.3	-	-	106	115	-
0.1	226	226	140	140	-

The independent gas chromatograph system has been used in previous CO measurement analysis and has been proven reliable. (2, 3, 4). The gas chromatographic data represent an *in situ* point source measurement while the GFCR represents a column burden measurement. To relate the data obtained by the *in situ* analysis and the GFCR, it was necessary to calculate an integrated atmospheric column burden bounded by the height of the sensor and the surface, using multiple ambient air sample bottle gas chromatographic measurements.

The GFCR and GC mixing ratios were compared at flight altitude and at several levels during the descent of the aircraft for the second flight. The comparison at flight altitude (6.1 km) was a column burden measurement comparison, and a relative difference of 4% was computed. A secondary comparison made at several descent levels is shown graphically in Figure 9. The relative differences in measurements range from 2% to 22%.

For the first flight the two systems were only compared at a flight altitude of 6.1 km. The results of this column burden measurement comparison indicated a relative difference of approximately 18%.

The large relative differences in the CO data measurements obtained during the descent of the second flight and at flight altitude of Flight I are a result of the same general factors. In both cases the radiative transfer calculations were performed using a CO profile uniformly distributed. However, the analysis of the GC CO data as shown in Figure 9 clearly shows that this condition was nonexistent in the atmosphere at the time of the CO measurements. In particular, gradients of CO



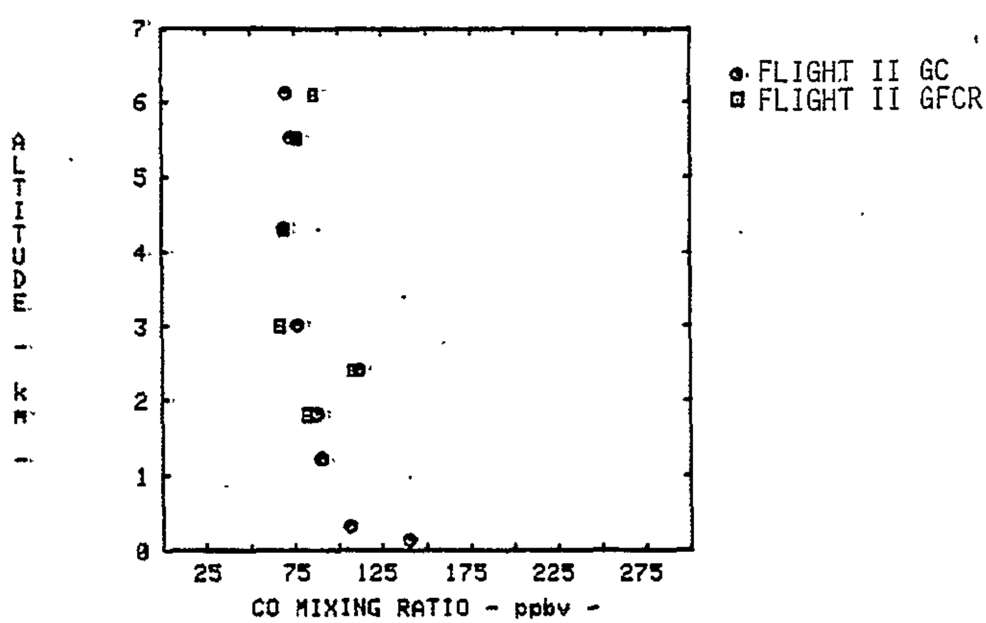


Figure 9. Plots of GFCR and GC vertical CO data.

were shown in the middle of the air column. An in-depth analysis of the temperature profile for the descent shows a temperature inversion to be located at approximately 2.5 km. Acting as a cap, this temperature inversion produced the CO gradient in the middle portion of the air column, which could result in a decrease in the accuracy of the measurements obtained by the MAPS GFCR. Therefore, the results of the GFCR and GC CO data comparison show that the GFCR CO values for these two flights are very reasonable.

Box Model

The CO data obtained from these two independent systems and the prevailing meteorological conditions can be used in conjunction with a CO emission inventory in applying a conservation of mass model to the study area. In order to perform these conservation of mass calculations, a source estimate of CO is required. This estimate was obtained from 16 traffic counting stations which were strategically set up to monitor the flow of vehicular traffic into and out of the study area. The station locations are shown in Figure 10.

To perform the mass conservation calculations utilizing the data described above the Flight I in the St. Petersburg area, the following assumptions are made:

- Sources are uniformly distributed. (Determined from the highway network.)
- Rate of emission of pollutant per unit area is constant.
- The net diffusion of pollutants to the sides are neglected. (The winds did not vary much over the time

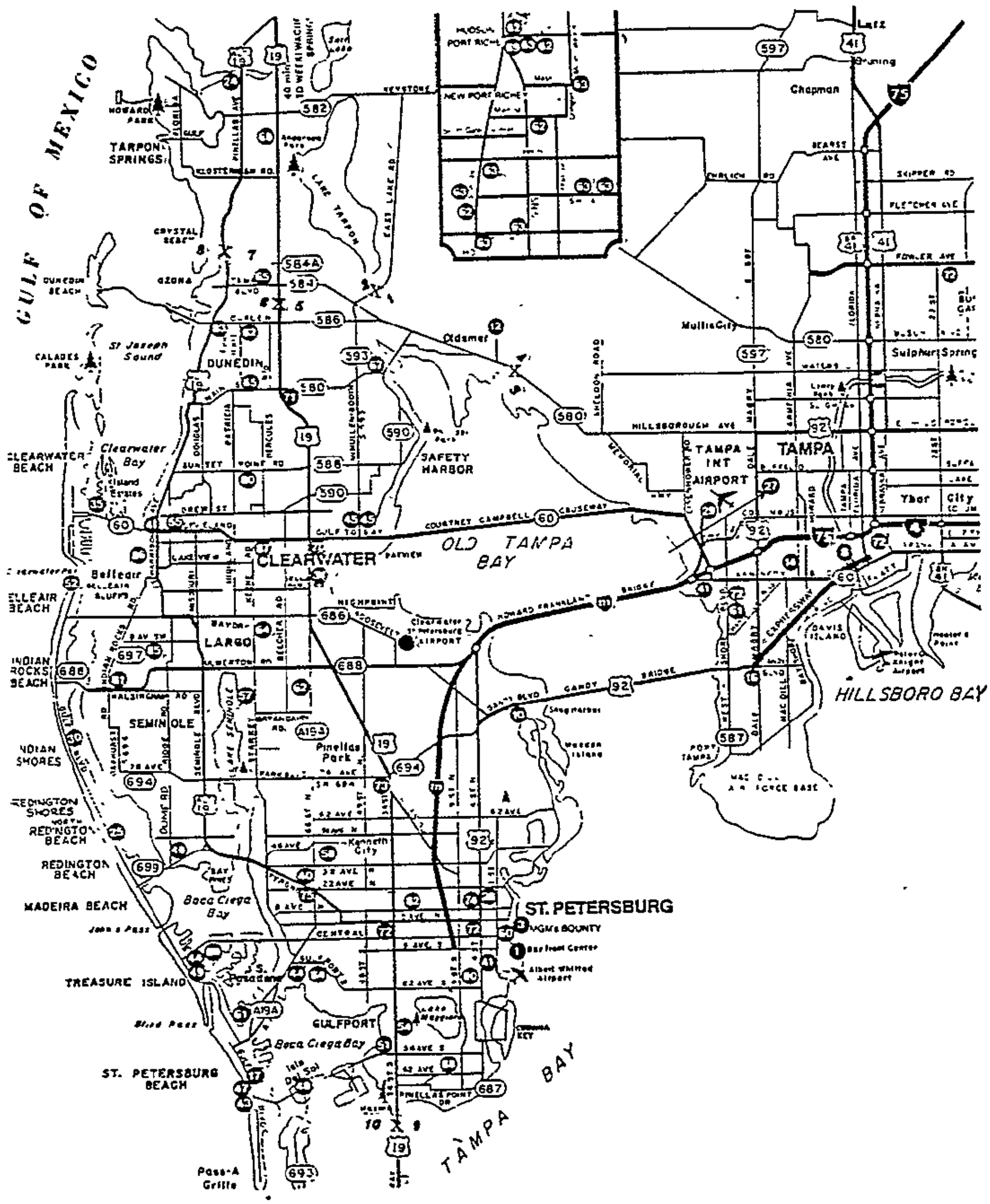


Figure 10. Traffic counter locations.

of interest.

- A series of closely spaced line sources was assumed. (Determined from highway network.)
- Only automobile emissions are to be considered. (No industrial sources inside area of interest.)
- Automobile emission of 112 g/day was used. (5)

Between Flight I and Flight II the atmospheric conditions transitioned such that for Flight II several of the assumptions required to perform the mass conservation calculations for an area source were violated. Consequently, the results of the mass conservation calculations for the second flight were not performed.

To compute the expected CO mixing ratio for the first flight, given the previously mentioned assumptions, Equation (1) was used. (6).

$$\chi = \frac{2 \times (Q/L^2)}{(\pi \cdot \overline{u} \cdot D_z)^{1/2}} X^{1/2} \quad (1)$$

Where χ is the computed concentration, Q is the emission rate, L is the length of a side of a surface area of a square, $\overline{u}$ is the average wind speed, X is the distance to be traversed, and D_z is the eddy diffusivity.

The volumetric mixing ratio Q_V was computed according to Equation (2)

$$Q_V = 22.4 \times 10^{-3} (Q_m/M_p) \cdot (T/273) \quad (2)$$

where Q_m and M_p are the mass emissions and molecular weight, respectively, of the gas species of interest, and T is the surface temperature.

The results of the box model calculations for Flight I show an increase in the mixing ratios of CO of approximately 35 ppbv as the source area is traversed from point A to point B (Figure 11) and a 28 ppbv increase from point C to point D (Figure 11). The computed increase is approximately 22% higher than the background mixing ratios of CO measured by the GFCR over the eastern portion of the ground track at an altitude of approximately 6.1 km.

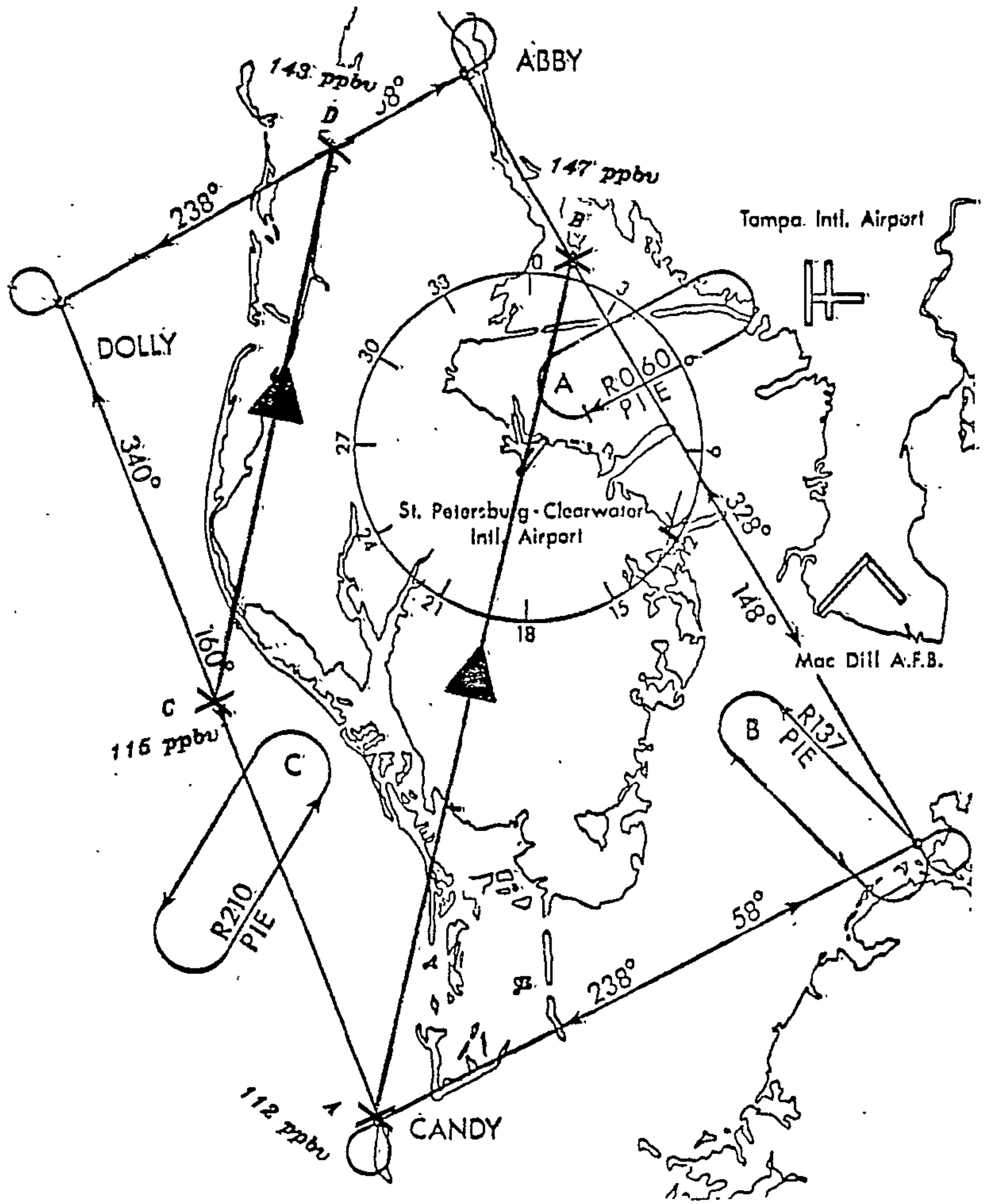


Figure 11. Area of the box model.

SUMMER MONEX - MID-ALTITUDE

The MONEX (MONsoon EXperiment) of 1979 represented one of the most intensive scientific measurement projects which investigated the atmospheric interhemispheric transport in the Indian Ocean area. The research performed utilizing the MAPS CO experiment measurements and the GC measurements, represents a very complex set of data obtained from a mid-altitude flight program. Specific tasks accomplished include:

- production of a comprehensive set of meteorological data to Dr. Reginald Newell of M.I.T. and Ms. Estelle Condon of NASA/Ames Research Center. This data was used to analyze the atmospheric interhemispheric transport of carbon monoxide during the MONEX test period. A publication on the results of this analysis is currently in print.

- categorization and sorting of all MAPS radiometer data for efficient data reduction. This task included the development and performance of background target sorting schema. In addition, calibration analysis was automated, decreasing, by a factor of four, the time required for processing large numbers of calibration data sets.

- verification of meteorological models utilized for the microprocessor real time data reduction.

- development of a more efficient and faster comprehensive data reduction methodology for the GFCR post-data reduction. This resulted in an approximate factor of 75 reduction in the cost of the interpolation process.

MAPS/OSTA-1 EXPERIMENT

Research tasks during this reporting period have included major organizational, developmental, and operational work in support of the MAPS/OSTA Experiment successfully flown on STS-2 in November 1981. This work involved considerable time and effort in pre-mission and mission planning and operations. The major task areas of work were:

- performance of STS-2/OSTA-1 MAPS Experiment signal interpretation, calibration and integration testing.
- providing meteorological support data for aircraft and MAPS Space Shuttle associated operations.
- developing a preliminary data management plan for MAPS/OSTA data reduction.

Comprehensive information on the details of the work performed in these task areas will be forthcoming in technical reports on each of the specific accomplishments.

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